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THE ENGINE: THE HEART OF THE AIRPLANE
AVIATION COMMITTEE OF THE BAR ASSOCIATION
DESIGN OF RECORDING WIND TUNNEL BALANCES

THE GARDNER, MOFFAT CO., INC.
HIGHLAND, N. Y.
225 FOURTH AVENUE, NEW YORK

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AVIATION AND AIRCRAFT JOURNAL

Vol. X JANUARY 31, 1921 No 5

Aircraft Insurance

IT is most satisfactory to know that insurance underwriters are taking a real interest in aircraft insurance. Besides writing policies they have, as a recent statement in AVIATION AND AIRCRAFT JOURNAL indicates, delegated to the Underwriters' Laboratory the difficult task of classifying aircraft for insurance purposes.

Here is a breaking of new ground, and the possibility of great good and possible harm to the industry.

Automobile insurance scarcely offers a useful precedent, since it follows classification according to price, and scarcely touches on the engineering and safety features of the automobile. Marine insurance probably provides the most promising field for study.

While in every important shipping country, there is a government agency of one kind or another licensing and inspecting ships, underwriters have never been content to take government licenses as a basis for underwriting insurance. They have preferred to form their own bodies, such as the "Veritas," "Lloyd's Register" and similarly well known organizations, which inspect and examine ships in a thorough manner, and then place such ships on a regular register. Such registers not only take care of the engineering and safety of the ship as it is laid down and built, but also register the career of each ship, giving its length of service, mishaps if any, reconstruction if any.

It would seem extremely useful if the Underwriters' Laboratory undertook work of a similar character. Its problem would be first to adopt a classification and a register as regards aircraft alone, and to adopt certain standards, then to consider aircraft engines, finally to consider routes of operation, rules for ground organization, qualifications of pilots, navigators and mechanics, and similar matters pertaining to the commercial operation of aircraft.

There is just a possibility of harm in this. The industry bears cheerfully the variety of government specifications it has to meet, since the government is perhaps its most important customer. It would bear with considerable ill will the burden of ultra severe insurance rules and regulations particularly if these were superimposed on a system of government licensing to be required sooner or later.

But, if the insurance authorities adopted a reasonable and broad-minded policy toward the industry many most desirable results would follow.

At present aircraft insurance premiums are high. Underwriters are working in a new field, they have little or no authority to follow and naturally have to safeguard themselves. Given an authoritative classification, there is every reason to believe that a reduction in premiums would follow.

The imposition of reasonable rules and regulations would serve as a bar to the building of unsafe craft, or of reckless operation. This would scarcely work hardship on deserving and skilled builders and operators, and by eliminating a few undesirable planes or badly operated enterprises from insurance possibility, would strengthen the standing of the industry as a whole. In obtaining credit for aeronautical enterprises, the securing of insurance on reasonable terms would be of tremendous value.

These are but a few of the benefits which a sane insurance policy would confer on the industry, and it is certainly desirable that this important problem be solved in a prompt, yet thoughtful manner.

Airplane Speed

IN the old days long ago the street cleaning departments of cities relied on windy days to make records in getting their task accomplished quickly. Airplane speed records in the old days also included some of the acceleration due to favorable atmospheric conditions. The F. A. I. requirements that all speed records that are to be considered official must be made over a course of four kilometers to three hundred and twenty-three kilometers in four flights, two with and two against the wind. The average speed of the four flights taken over the same length of course as the record speed, is correct in principle. The averages should be of the respective speeds figured separately in each direction and not the total mileage divided by the elapsed time.

In future speed contests in this country this plan should be followed where practicable as it would create a certainty in the minds of everyone that the speed was not due to any outside influence. Attention should also be given to the altitude requirements so that the start and finish would be at the same heights which preferably should be standardized so that comparative speeds of airplanes could be calculated.

Engines for Commercial Aircraft

PERHAPS the point which brought out more discussion than any other at the S. A. E. Aeronautic Conference was Grover C. Loening's statement that engineering opinion in this country and abroad was in favor of single engine types for commercial aircraft. An opposite point of view was expressed by Prof. E. P. Warner, of the Massachusetts' Institute of Technology, who has recently made an extended trip studying the aircraft situation in Europe. He gives as his opinion that not only are the two or three engine type used but that in his opinion the multi-engined airplane will be the ultimate commercial air vehicle, when traffic becomes so stable that such aircraft can be flown with full loads.

Undoubtedly at the present time when air travel is becoming established and the flow of traffic is unequal, the smaller unit is more economical but with growth of the business, the tendency will probably be toward larger units the same as has been true of railroad and steamship development.

Some Experiments with Model Airplanes

By Albert A. Merrill

California Institute of Technology

In an article published in AVIATION AND AIRCRAFT JOURNAL for November 29, 1920, experiments with a model of the Curtiss JN-4 were described. This article will describe some experiments with a model which is a modification of the Boeing Navy training plane. The machine as constructed by the Boeing Airplane Co, of Seattle, Wash., is a seaplane having pontoons but for purposes of comparison with the Curtiss land machine the model was made with wheels.

The distinguishing feature of the model, which was in fact the reason it was chosen for a test, is the stagger-decalage disposition of its main supporting surfaces. The model shown in Fig. 1 represents the stagger-decalage type of machine in that it has a stagger, positive decalage and no fixed tail surface, control in pitch being by balanced elevator

Fig 2 shows the pitching moment graphs for the Curtiss, previously published and Fig 3 shows similar graphs for the

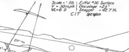

FIG. 1

modified Boeing The X graphs represent pitching moments with no elevator The other graphs represent moments for different elevator settings. For the Curtiss, 0 deg setting means the elevator is continuous with the tail. For the stagger-decalage machine, 0 deg setting means the position shown in Fig. 1.

The first thing to note is that the X graph for the stagger-decalage is more nearly horizontal than is the X graph for the Curtiss (the scales are the same for both cases) This should mean less stiffness for the stagger-decalage machine, less static stability but less violence of return to normal altitude in gusty weather The next thing to note is the difference in slope between the X graph and the other graphs for each machine. This difference is greater for the stagger-decalage model than for the Curtiss. This should mean that the pilot of the stagger-decalage machine will have better control in pitch than will the Curtiss pilot. This better control is also shown by the fact that for a given change in elevator setting the graph is displaced on the angle of incidence farther than in the Curtiss.

As Dr Bateman has suggested, a good way to measure a pilot's control is to plot settings of the control surface on the angle of incidence for which the moment is zero Measured in this way the Boeing is superior to the Curtiss. The reader should remember that these figures are direct from model tests and no scale corrections have been applied.

Quite a number of experiments with models to determine pitching moments on angle of incidence with different elevator settings have been made in England and the results are published in the Technical Report of the Advisory Committee for Aeronautics for the years 1913-14. In tests on the BE-2 type the results show that the righting moment contributed by the fixed tail is much reduced by the fact that the tail is in the wing wash Quoting from page 135

"This question of the interference of the main planes with the tail plane is of great importance in the design of airplanes particularly biplanes, especially as the effect may be, as in the present case, sufficient to reduce the efficiency of the tail (from the point of view of introducing a righting moment) to that of one of half the area."

It must be remembered that these experiments were made with a model in a wind tunnel and represent only gliding flight

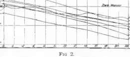

FIG 2.

without power Under these conditions it was found that the position of the tail, as a stabilizing surface, was bad owing to the wing wash. What must we say then of its position with power, under which condition its righting couple must vary with the r p m of the engine which determines the air speed of the tail? As it happens tests have been made showing the effect of screw slip stream on stability and we shall refer to these tests later but quoting again from the British report, page 109

"It has been pointed out in the two previous sections that on this model biplane, the righting moment due to the tail, including the elevators is reduced to approximately half its value owing to the effect of the wash of the main planes. Since a large part of the righting moment due to the tail is required

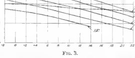

FIG. 3.

to balance the movement of the center of pressure on the main planes, this reduction due to the wash of the main planes is of serious importance, and it was thought desirable to investigate the direction and velocity of the wash in the neighborhood of the usual position of the tail with a view of finding if possible some position which would give improved conditions."

Tests were made with the tail and elevator in nine different positions covering all the practical positions for those surfaces. About these tests the report says: "So far as the measurements have yet been carried no considerable improvement in the conditions under which the tail plane and elevators work has been obtained The reduction in effective area due to the wash of the main planes was still 60 per cent for all positions tried."

Turning now to some free flight tests, see what is found. These tests were carried out at Langley Field and form the basis of Report No 70 N.A.C A. The title is "Preliminary Report on Flight Tests." The machine of interest to us is the Curtiss JN-4.

Quoting first the statement in this report which makes us uncertain just how to apply scale corrections. On page 22

the report says. "The indication is that the slip stream effect and the various crudities of construction on the model (such as the use of round wire interplane struts) are almost exactly counter balanced by the 'scale effect' and by the effect of the omission of wires fittings, etc from the model." This is why we are in doubt just how to apply the scale corrections. Certainly it seems advisable for aerodynamic laboratories to test with the slip stream present if possible.

Consider now the flight tests. The c g for the JN-4 used in the tests was 39 per cent back from the front edge of the

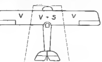

FIG. 4.

mean chord (a chord parallel to the wing chord but 60 per cent. of the vertical gap above the lower wing) "This is materially farther back on the wings than the usual location for the c.g Translated into practical terms this means that if the stick were locked in position while the machine was climbing with an open throttle, so that the elevator settings could not change, whatever might be the forces acting on the control surfaces, and the throttle were then closed, the nose of the airplane would drop and would continue to go down at least until the speed of the dive reached 90 m.p h and probably until the airplane passed the vertical and attained an upside down position"

On page 26 we find "It will be noted that the range of speed for stable flight with fixed controls and fixed throttle setting becomes wider in general as the engine speed is decreased and that for the lowest curve (engine idling) there is no sharp negative slope at any point With the throttle wide open on the other hand the machine is unstable for practically the whole speed range." "Engine idling" corresponds to conditions under which models are tested and I found the Curtiss stable under these conditions but we had the c.g (assumed) much farther forward namely 24 6 degrees back from the front edge of the mean chord instead of 39 degrees and also had placed the c.g a little lower In this report it is suggested that this particular JN-4 would perhaps be improved if the c g were only 28 degrees back on the mean chord and this agrees with tests here and also with tests made at the Curtiss laboratories. We found the model stable for all elevator settings The National Advisory Committee's report indicates that the machine was unstable for practically the whole speed range (equivalent to different elevator settings) if the throttle was wide open.

Now the question is Is this instability caused by the position of the c.g or by the slip stream or by both? It can not be due to the wing wash because that is present in model tests where there was stability. The position of the c.g may account for some of the instability (see Curtiss laboratory tests mentioned above) but it is certain that the slip stream alters the air speed of the tail and this must affect stability in pitch. A change in the magnitude of the slip stream alters the total force on the tail a greater percentage than such a change can alter the force on the main surfaces because the slip stream affects a larger portion of the tail than of the main surfaces

The pitching moment being the resultant of two couples about the c.g, namely, that from the main surfaces and that from the tail, it is certain that a change in the slip stream will alter the ratio of these two couples and so alter the magnitude of the pitching moment. If, in Fig. 4 V equals the speed of the whole machine through the air and S the mean speed of the slip stream then that center portion of the machine lying between the dotted lines will have an air speed of $V + S$ and the rest of the wings an air speed of only V. Is it not certain that any change in either V or S (provided $S > 0$) will alter static stability? The report admits this when it states that with the throttle wide open ($S > 0$) "the machine is unstable for practically the whole speed range." These experiments prove then that stability is affected by the fact that the tail is in the slip stream.

In the stagger-decalage machine stability is produced by the stagger decalage disposition of the main surfaces and there is no stabilizing surface in the slip stream. It is hard to see why this is not an improvement over the tail machine.

The cure for this instability in the JN-4 is probably just what the British suggested, namely, a trim so that there is considerable downward pressure on the tail

Turn now to Technical Notes No 1 N A C A and on page 5 we find: "For example there is under all ordinary conditions of flight, a downward load on the stabilizer or tail plane and a section flat on the lower surface like that employed on the JN-4 is therefore working at a negative angle of attack, a condition in which the lift curve has a materially smaller slope than it has for positive angles.

"It might therefore be expected that the stabilizing effect of the tail planes of the JN would be improved by inverting the section making the upper surface flat and the lower one cambered and this has been found to be the case" In other words, the tail is in such a bad position that to improve things it is redesigned so as to press downward still more than it did originally

In the Boeing machine stability is obtained by lifting surfaces which are not in the wing wake or slip stream. So far as static stability in pitch is concerned we can get an X graph by doing away with the tail and arranging for the proper decalage and stagger, which graph will be as good as any that can be obtained with a tail Fig 3 shows such a graph.

Laboratory tests of this system were made by Dr. Hunsaker at the M I.T. and the results were published in *Engineering*, London, for January 7 and 14, 1916, under the title of "Stable Biplane Arrangements." Referring to the combination of + 2½ deg, decalage and + 60 per cent. stagger Dr. Hunsaker says Vol. 101, page 26, *Engineering*: "The result appears to be a happy one." He finds the following characteristics of this disposition compared to the standard biplane (no stagger or decalage) Maximum L/D 5 per cent less, maximum L 3 per cent more Where K_y is 0 0005 the L/D is the same for both but where K_y is 0 0016 the staggered decalage system gives the L/D 2 per cent better. This means that for high speed there is a no difference and for low speed the stagger-decalage system is the better Also the range of the flat burble point is twice as great as in the common type

With the stagger-decalage tailless system the wash and slip stream can have no effect upon static stability in pitch. In as much as doing away with the tail means a saving in cost and dead weight which must more than equal the cost of longer struts and wires due to more stagger, it is strange that the tail persists as a part of the airplane..

ED NOTE: Mr. Merrill's article is interesting, and is published as a plea for a machine in which static longitudinal stability is secured by decalage instead of a non-lifting tail. The remarks on the effects of slip stream are interesting and no doubt justified. But it is also quite certain that adequate static stability can be secured by the use of a non-lifting tail. Mr Merrill has also omitted all consideration of dynamic stability. Most of the damping in dynamic stability is due to the tail surfaces, and with a tailless machine it is doubtful whether sufficient dynamic stability would be secured. With a stabilizer and elevator system also; owing to the interaction of elevator and stabilizer, a much smaller effect is demanded from the elevator to secure control, and this is a great advantage from the pilot's point of view The gain in weight by omission of a stabilizer would also be relatively unimportant

School of Aviation in Ecuador

The Ecuadorian Congress during a recent session authorized the establishment of schools of aviation in Guayaquil and in Quito The services of foreign experts are to be solicited, and funds are to be raised and appropriated for the maintenance of these schools.

Airplane Cost in Hydro-Electric Work

By Ernest W. Dichman

In 1909 when Orville and Wilbur Wright first made a successful attempt at flight in a heavier-than-air machine, the airplane was looked upon as an interesting invention and few people beyond the most visionary predicted that it would serve any useful purpose or even be more than a mere curiosity.

Under circumstances such as these it is not surprising that the development of the airplane progressed rather slowly until the beginning of the war in 1914. Not long after the commencement of hostilities the airplane proved its value as an aid to military operations, first for purposes of scouting and artillery observation, later for bombing, and finally in the development of the single-seater fighter as a combatant arm of the service.

The rapid development of the airplane produced a wealth of technical information unparalled in the history of any science, and it can be said without exaggeration that during the war the science of aeronautics made a stride equivalent to fifty years of peace time development.

Consideration of Commercial Possibilities

The post-war period, while not furnishing so great a stimulus to airplane development as war conditions made possible, permitted the airplane to develop in a firmer and more stable manner. Quite naturally its commercial possibilities were considered, and as a result we have the London-to-Paris aerial transport service, the aerial mail, and a large number of smaller transportation projects. The peace time uses to which airplanes may be put are many and varied, but in any event, whether they be used for transportation of people or materials, for advertising, mapping, photography, forest patrol, or merely for pleasure and sport, the problem in its final analysis is one of costs in proportion to service rendered,—initial cost and costs of operation and maintenance. In order to prove itself a sound investment any plan for the use of airplanes must earn a substantial income or else perform some function more efficiently and economically than existing methods permit.

Adaptability to Mountain Construction Work

A plan for the use of airplanes which should be of particular interest to engineers of the Pacific Coast generally is its employment as a carrier of men and material in connection with construction work in the mountains. This applies equally well to mines, hydro-electric developments, or the construction of water supply systems. Often the construction camp is but a few miles distant from the nearest railroad station, yet because of the character of the terrain the haul is a long and consequently expensive one. The airplane can here be used to transport men and material, often eliminating the necessity for building a road, or used as an adjunct to motor haul, may keep the construction camp supplied during seasons when roads are impassable. The airplane is also exceptionally well adapted to the rapid transport of officials from the main office, or of small but vital pieces of machinery from the factory in cases of emergency to any power house, substation or construction camp. The distances in such cases often run into hundreds of miles, and the time consumed in transit would be reduced from days to hours.

Factors in the Success of Aerial Transportation

Let us first examine the necessary characteristics for a successful aerial transport system. Listed in order of their importance they are as follows:

I. Safety
II. Reliability
III. Speed
IV. Costs in proportion to service rendered.

I. Safety in Flight

In times of peace safety in flight is undoubtedly the most important consideration. No one would be justified in taking unwarranted risks with human life to secure greater speed or lower costs of operation. Unfortunately there exists in the mind of the uninitiated a firm impression that flying is a very hazardous occupation and for that reason many people are timid about making a flight. In this connection an article quoted below from the Boston *Transcript* of December 11, 1919, serves to refute the popular impression on the danger of flying as a commercial proposition.

"**British Register 21,000 Aerial Trips in Six Months with Only Two Fatal Accidents. None of 52,000 Passengers Killed**

"London, December 11.—Statistics of the safety of civil aviation are given in a synopsis published by the Air Ministry of progress between May 1 and Oct. 31. The figures (approximate only) are as follows:

Number of flights	21,000
Number of passengers	52,000
Mileage	303,000
Accidents	13
Fatal accidents	2

"Both the fatal accidents happened to pilots. Six pilots and ten passengers were injured, or one passenger injured for every 5,200 carried."

Statistics on file with the Air Service show that less than 5 per cent of all accidents which do occur are due to defects of the airplane structure, and the remaining over 95 per cent of accidents are due to the pilot's carelessness or poor judgment. Safety in flight is really measured by the pilot's ability, and a careless pilot, as a careless chauffeur or locomotive engineer, can endanger the lives of his passengers. It will not be possible to digress in order to explain what constitutes a first-class pilot. Sufficient to state that it requires a long training combined with natural common sense, and a lack of any desire to play the fool. During the war a great number of excellent pilots were produced.

II. Reliability

Reliability of a service such as proposed would be measured by its ability to run on scheduled time in spite of severe weather or other causes for delay. The most important factors contributing to the reliability of an aerial transport service are the ability of the engineering force properly to maintain the airplanes and engines and keep them in perfect condition; the kind of weather encountered in the territory to be served, and the ability of the pilot to use his engines as advantageously as possible and not to abuse them.

An indication of the extent to which airplane operation can be relied upon may be obtained from the records of the Aerial Mail Service between New York and Washington for the fiscal year July 1, 1918, to July 1, 1919, given below:

Total number of trips possible	1,435
Total number of trips attempted	1,087
Number of trips defaulted	47
Number of trips in fog	511
Number of trips in clear	618
Total number of miles traveled	160,066
Per cent of performance	88.81 per cent.
Number of forced landings due to motor trouble	36
Number of forced landings due to weather	65

A per cent of performance varying from 83 per cent in the winter months to 95 per cent in the spring and 99 per cent in the summer and fall, giving an average of 94 per cent for the year, is a very encouraging figure. Especially so as the climate along the Atlantic coast is very severe with extensive ranges of temperature for summer and winter. With mild winters such as are common in California it is certain that the figures of 80 per cent for the winter months would be considerably bettered.

III. Speed

Speed of course is the big advantage of aerial transport. In addition to a flying speed of from 100 to 125 miles per hour characteristic of our latest machines, it is possible to steer a direct course for the objective instead of having to take a circuitous route and follow the contour of the terrain as in the case of railway or automobile. This last point is an important one in the consideration of the use of the airplane as an aid to hydro-electric construction. To illustrate let us say, for example, that the camp is twenty miles distant from the nearest railroad by air line and at an increase of elevation of 4,000 feet. Assume the haul by road is forty miles, which being twice the air line distance is a fair estimation. Under circumstances such as these a motor truck would make the round trip in two days, while mules would require at least four days for the round trip. For an airplane with a speed of 90 miles per hour, one hour would be sufficient time for the round trip and include one-half hour for loading and unloading. On the assumption of an eight-hour day this means that the airplane is sixteen times as fast as motor trucks and thirty-two times as fast as mules.

II. Costs in Proportion to Service Rendered

Let us now turn our attention to the important subject of the cost of such a system. Of course, no detailed statement of costs can be made until we know the particular conditions under which such an aerial transport system is to operate. These particular conditions are listed below:

1. The length of the air haul which would be equivalent to the air line distance between the two points.
2. The difference in elevation between the two points.
3. Approximately the total amount of material to be hauled, and the character of this material—namely, bulky or compact.
4. The availability of landing fields at both station and camp, and the character of the intervening country.
5. The weather conditions encountered in the territory to be served.

Upon a study of the above conditions the following points can be tentatively decided:

1. The size and type of airplanes.
2. The number of airplanes.
3. The number of trips per day and the schedules.
4. The load to be carried per trip.

Costs may then be divided into initial cost, maintenance cost, and depreciation.

Initial costs include:

1. Purchase of airplanes.
2. Preparation of landing fields.
3. Erection of hangars and machine shops.

Maintenance costs include:

1. Maintenance of airplanes.
2. Maintenance of landing fields.
3. Maintenance of hangars and machine shops.
4. Salaries of pilots and mechanics.

Depreciation includes:

1. Depreciation of airplanes.
2. Depreciation of hangars and machine shops.

A study of the above costs for any particular set of conditions permits us to predict with considerable accuracy the cost per ton and hence the cost per ton mile of transporting material from railroad to camp.

Referring to our previous example, where a twenty-mile air haul was equivalent to a forty-mile road haul, it was shown that an airplane was sixteen times as fast as a motor truck and thirty-two times as fast as mules. This means that an airplane capable of carrying 3000 pounds load could take the place of five 5-ton trucks or of sixteen 3 ton wagons each drawn by four mules. Allowing one pilot for each airplane each pilot would take the place of five chauffeurs or sixteen teamsters.

The cost of constructing and maintaining a road from station to camp is an exceedingly large item. With aerial transportation in place of this expense there would be the preparation of two landing fields which often would not require a day's work to be suitable for their purpose.

In order that the economies to be effected by employing aerial transport may be definitely brought out, a direct comparison has been made between the costs of hauling by motor in connection with construction work in the mountains and these same costs had aerial transport been employed.

Costs of Motor Transportation

In 1917 the cost of motor hauling on mountain roads ran about 35 cents per ton mile, exclusive of the cost of road construction and maintenance, so that it is safe to assume that present day costs would be approximately 50 cents per ton mile. The cost of mountain road construction is about $15,000 per mile and maintenance $500 per mile per year.

Now let us apply these figures in the case of a construction project in which the following conditions exist:

The air line distance between the nearest railroad and the construction camp is 20 miles.

The construction camp is at an elevation of 4,000 feet above the railroad.

The road connecting railroad and camp is 40 miles.

The project is the construction of a dam, so the material to be transported would be mostly cement.

The total amount of material to be transported is 15,000 tons.

The duration of the job will be approximately two years.

The ground at the reservoir site will have to be cleared anyway, so the expense of a landing field at this end need not be charged to the aerial transport.

The landing field at the station could be prepared for less than $1,000.

The weather in the winter is rainy, rendering the roads impassable for three months.

The cost of hauling by motor would be as follows:

Road construction, 40 miles @ $15,000 per mile	$600,000	
Road maintenance, 2 years, 40 miles @ $500 per mile per year	40,000	
Total cost of road over two years		$640,000
Direct operating costs of hauling 15,000 tons over 40 miles @ 50c. per ton mile		300,000
Total cost of hauling, including cost of road		$940,000

NOTE.—The depreciation and repair of trucks, and salaries for chauffeurs and mechanics are all included in the figure of 50c. per ton mile.

The road would of course have no salvage value so that no rebate could be obtained from that source, and therefore the net cost of hauling 15,000 tons of material in two years by motor from the railroad to the construction camp, 20 miles distant by air line and at an increase of elevation of 4,000 feet, entailing a road haul of 40 miles, is $940,000.00, or $1.57 per ton mile.

Let us now investigate the cost of hauling this material by airplane.

Aerial Transport Service Cost Data

For this service we should use two bi-motored airplanes patterned after the bombing airplanes in use during the recent war, but modified by using a high lift rather than high speed wing section, and possibly slightly increasing the area of the wings so that each machine would be capable of carrying 3,000 pounds of useful load.

The power plant of each machine would consist of two Liberty 12 engines each delivering 400 hp. at 1700 r.p.m., but ordinarily operated throttled to 310 hp. and 1600 r.p.m. The average speed under these latter conditions will be 90 miles per hour.

Fuel capacity can be limited to one hour as the round trip can be accomplished in less than half that time. Airplanes will be fueled after each round trip.

Each airplane will make 8 round trips a day. As the air haul is only 20 miles this will allow one-half hour per trip for loading and unloading.

Each airplane will then be actually in the air less than 4 hours per day so that during one year of 313 days it will have flown 1,252 hours, after which it will be salvaged for 25 per cent of its initial cost. This figure is purposely placed extremely low, as to keep each machine in the air 1,252 hours will require 20 per cent of the original cost expended in replacement parts.

During one year's operation two sets of engines will be used and salvaged. The total running life of each engine will then be 626 hours. The salvage value of each engine will be 50 per cent. During the life of each engine it will be completely overhauled six times and at each overhauling 10 per cent of its original cost will be expended in replacement parts.

A Liberty 12 engine consumes approximately 26 gallons of gasoline per hour when delivering 310 hp. at 1600 r.p.m., so that two bi-motored airplanes actually in the air four hours each day will consume during a year of 313 days 130,208 gallons of gasoline. Allowing approximately 20,000 gallons per year for taxiing, testing spare motors and wastage, the total gasoline consumption will be 150,000 gallons per year.

Oil consumption is less than one gallon per engine per

hour, so that the total oil consumption would be 5,000 gallons per year.

A hangar and machine shop for the care of the airplanes will be erected at the railroad landing field only. This need be nothing more than a board and batten building where the initial cost is low but the salvage value is only 20 per cent of the original cost.

Three pilots will be sufficient to supply the necessary reserve in case of illness or relief in order to operate 10 or even 12 hours per day in case of emergency.

Total amount of material transported. As each airplane carries a load of 3,000 pounds 8 times daily the total amount of material hauled would be 2 airplanes 8 trips each, 3,000 lb per trip, 24 tons per day.

Working 313 days per year the yearly haul would be 7,500 tons, and in a two-year period 15,000 tons of material will have been delivered.

CAPITAL INVESTED AND EXPENSES

Property Investment		
Preparation of landing fields	$ 1,000	
Hangar and repair shop (for two airplanes)	12,000	
Machine tool and hangar equipment	5,000	
Office equipment	500	
Gasoline tank equipment	3,000	
Total property investment	$ 24,500	
Transportation Equipment Per Year		
2 airplanes @ $40,000 each	$ 80,000	
8 engines @ $4,000 each	32,000	
Airplane spares, 20 per cent. of airplanes	16,000	
Engine spares 60 per cent. of engines	19,200	
Material	10,000	
Total transportation equipment, per year	$157,200	
Over two-year period		$314,400
Direct Operating Costs Per Year		
Gasoline, 150,000 gals @ 30c per gal	$ 45,000	
Oil, 5,000 gals @ 75c per gal	3,750	
Total annual fuel cost	$ 48,750	
Over two-year period		$ 97,500

ANNUAL SALARIES FOR PERSONNEL

1 Superintendent of transportation		$ 6,000	
3 Pilots at $5,000 each		15,000	
1 Shop foreman		4,000	
2 Rigging mechanics	at $2400 each	4,800	
2 Rigger's helpers	at $1800 each	3,600	
3 Engine mechanics	at $2400 each	7,200	
4 Mechanic's helpers	at $1800 each	7,200	
2 Machinists	at $2400 each	4,800	
2 Machinist's helpers	at $1800 each	3,600	
1 Clerk and stenographer		1,800	
Total annual pay roll		$ 58,000	
Over two-year period			$116,000

OVERHEAD

Rent and upkeep of landing field	$ 1,200	
Upkeep of buildings	1,800	
Heat, light and power	1,200	
Insurance on buildings and equipment	600	
Office supplies	600	
Total annual overhead	$ 5,400	
Over two-year period		$10,800

NOTE—Depreciation considered in determining salvage value

ANNUAL COST OF OPERATION

Transportation equipment	$157,200	
Gas and oil	48,750	
Salaries	58,000	
Overhead	5,400	
Reserve for unforeseen expenses	10,000	
Annual operating expense	$279,350	
Over two-year period		$558,700

INITIAL INVESTMENT REQUIRED

Property investment		$ 24,500
Transportation equipment		157,200
Monthly working capital	Fuel and oil (approx.)	4,100
	Salaries (approx.)	5,000
	Overhead (approx.)	5,000
Total initial investment		$195,800

SALVAGE VALUES

Hangar and machine shop, 20 per cent	$ 2,400
Machine tool and hangar equipment, 80 per cent	4,000
Office equipment, 60 per cent.	300
4 airplanes 25 per cent.	40,000
16 engines 50 per cent.	32,000
Total salvage value	$ 78,700

NET COST OF OPERATION OVER TWO YEARS

Property investment	$ 24,500	
Operating expense for two years	558,700	
Total cost of operation for two years	$583,200	
Salvage value of buildings and equipment	78,700	
Net cost of operation for two years		$504,500

It is therefore seen that the cost of transporting 15,000 tons of material by airplane from railroad to construction camp 20 miles distant by air line is approximately $505,000. This represents a saving of $435,000 over the cost of performing the same task by motor truck, or a saving of $29.00 per ton in transporting the material from railroad to construction camp. The comparative figures are tabulated below:

Cost of transporting 15,000 tons of material 40 miles by motor	$940,000.00
Cost of transporting 15,000 tons of material 20 miles by air	505,000.00
Saving due to use of aerial transport	$435,000.00
Cost of transporting one ton of material from railroad to camp by motor	$62.70
Cost of transporting one ton of material from railroad to camp by air	33.70
Saving per ton due to use of aerial transport	$29.00

In addition to the saving in cost indicated the airplane has the advantage of being able to operate during the seasons when the roads are impassable, keeping the camp supplied with material and allowing the construction to proceed. Of course there are certain limitations to aerial transport, but only a study of the conditions in each particular case can determine whether or not the airplane can advantageously be used. Unfortunately, so much has been written about the airplane in a spectacular vein that this phase of the subject has in the past overshadowed its more useful purposes. However, the time has come for engineers to realize that the safe and sane development of the airplane is due to make it an important economic factor in our daily life, whose points of superiority may be taken advantage of by anyone having the initiative, energy and courage to do so.—*Journal of Electricity.*

Planning Permanent Air Service Stations

The Chief of the Army Air Service has under consideration the question of the present design of Army Air Service stations with a view to gathering information for the adoption of a design for permanent stations. While in most cases the buildings erected were constructed under stress of war conditions, the general plan was made after much study and has answered the purpose for which constructed.

Now that the general layout at Air Service activities has been under observation for considerable time, it is considered that commanding officers are in a position to give the office of the Chief of Air Service a great deal of assistance by making recommendations in connection with future construction. They have been directed to give this matter their particular attention and study. It has also been suggested that consultation with staff officers and others immediately concerned will bring forth much constructive criticism which will be of value to the commanding officer in making his final recommendations.

These recommendations are to include the general layout and the details as to design of building, storage space, shops, installation of equipment, etc. They are to differentiate between permanent and temporary installation, but there is no reason why the recommendations for permanent installations cannot be used as a model for temporary installations. It is not anticipated that the general layout plan, except perhaps for officers, and non-commissioned officers' quarters, will be materially different, the major difference being only in structural design and material used.

Makes Landing on One Wheel

Scores of officers and men at Mitchel Field were treated to a thrill recently, when Major Abbey, commanding officer of the Fifth Squadron, landed an SE-5 on one wheel. Unaware that he had lost his right wheel in taking off, the Major had led a couple of D-H's, sent up to appraise him of the fact, a merry chase for some time before the situation dawned on him. Although the machine turned turtle in landing, Major Abbey's coolness and skill saved both the machine and himself from serious injury.

The Engine: The Heart of the Airplane

By Col. Jesse G. Vincent

Vice-President of Engineering, Packard Motor Car Co.

A great truth in engineering was expressed by Abraham Lincoln when he said that a man's legs should be long enough to reach from his body to the ground. It is the same truth that engineers now refer to as "unity of design," and it means that a piece of mechanism, if it is to function properly, must be planned as a whole, and that no agglomeration of parts will be wholly satisfactory, no matter how excellent the individual parts may be. I am sure that no other man's legs, no matter how beautiful, would serve me quite so well as my own do.

This is a principle, however, that has only rather recently been applied to airplane design. The engine is, in truth, the heart of the airplane. So long as it beats, the plane is like a thing of life—ever responsive to the wishes of the pilot. But with the engine dead, the plane becomes a lifeless, inanimate thing which can only flutter to the ground, although it can be controlled through its final glide so as to insure safety to the occupants.

An airplane has been aptly described as an engine with wings. If we accept the truth of this bird-like simile, we have the fundamental basis for determining in what ways the relation between the engine and the plane should control the design of the plane itself.

Col. Jesse G. Vincent

The answer is, "in every possible way." The law of unity of design requires that the balance between the two should be perfect within the limits of human power, that the engine should be designed to fit the plane and the plane designed to fit the engine. The more thoroughly the designs of the engine and plane are coordinated, the better will be the final result. If the designs are in harmony, the plane should excel in whatever qualities have been sought, whether they are in high speed, ease of maneuvering, ability to carry loads, economy, low landing speed, safety from fire, low head resistance, ease of vision, reliability, endurance, etc.

The question of wing design is not related to the power plant design, except that they must both conform to the general specifications laid down for the plane. The detailed specifications to which both the engine and wings must conform are usually about as follows:

(1) Load to be transported.
(2) Maximum speed of plane.
(3) Minimum speed of plane.
(4) Radius of action of plane.
(5) Ceiling, or maximum altitude plane is capable of flying.
(6) Climbing speed or rate of climb.
(7) Type of service, that is, over land or water.
(8) One engine or more.

When these have been determined, it is possible to carry out the engine design along well defined lines.

The first thing to be determined is the horsepower that the engine must produce. This is calculated on the basis of certain aerodynamic conclusions which are reached by taking into consideration the requirements of the lift, speed, resistance, etc. and also, of course, of propeller efficiency.

Along with this goes the question of the engine speed at which the desired horsepower is to be obtained. In general, for fixed propeller efficiency, there is a fairly definite relationship between propeller speed and airplane speed. This has an important influence on the type of engine employed. For example, a high speed scout plane will use an engine capable of turning its propeller up as high as 2,000 r.p.m., or more to get a speed of 150 miles an hour or better, whereas a heavily loaded seaplane may have a maximum speed of 90 miles an hour with a propeller speed of only 1,200 r.p.m.

There also enters into this phase of the design the question as to whether the engine is to be connected with the propeller directly or through a reduction gear. The latter construction has certain advantages for the lower speed planes, since the engine can be a reasonably light, high-speed type and the propeller can be of a large diameter and run at a comparatively low speed. These two conditions are favorable to high propeller efficiency for speeds of around 80 miles an hour.

Attempts to use reduction gears have given considerable trouble in the past, since slight variations in the engine torque are opposed by a more or less constant propeller load so that the gear teeth are subjected to violent chattering and shock, which are very injurious to the mechanism.

There is a tendency in some quarters to favor the use of slow-speed, directly connected engines which may be somewhat heavier than the high-speed geared engines but are likely to excel the latter in reliability, endurance and economy. But if a spur geared engine is chosen, the propeller shaft is usually located above the crank-shaft, and this may exercise a considerable influence on the design of the plane.

The correct balance of the plane, or its automatic tendency to fly on a level at full or nearly full throttle, depends upon several factors. Among these is the relationship between the center of thrust from the propeller, the center of pressure from the air, the center of gravity from the distribution of weight, and the center of lift to be determined by the angle of the planes, etc. Of these factors, the engine design determines the center of thrust and the knowledge of its location is absolutely essential to the plane designer. The location of the engine also affects the center of gravity and is, therefore, equally important.

The general lay-out of the engine also plays an important part in the design of the fuselage in which the engine is to be mounted. As a general rule, it is desirable to keep the cross-section area of the fuselage down to a minimum, that is, to make the fuselage as shallow and narrow as possible, in order to decrease the resistance of the plane to the air. The shape of the fuselage, of course, is not determined entirely by the engine but depends also on the arrangements for the seating of passengers and for the fuel tanks. Nevertheless, the design of the engine largely controls the factor of the fuselage head resistance. It also has a bearing on the matter of the pilot's field of vision, which is an important point in the design of either war or commercial planes.

Another feature of the plane design which is vitally affected by the engine is the fuel storage and supply. In long distance planes, the fuel weight is a very large item and it is essential that the fuel be stored in such a way that the balance of the plane will not be seriously altered as the fuel tanks become nearly empty at the finish of a flight. This means that the fuel tanks must be arranged symmetrically with respect to the center of gravity of the plane.

Of course, it is obvious that the more economical the engine is in its fuel consumption, the more desirable it is from the point of view of plane design since the economical engine will have a correspondingly lighter load at the start of the trip. Thus we see that it is essential for the plane designer to have accurate data on the engine's fuel consumption in order to enable him to calculate the maximum load which the airplane will have to lift.

These are the main points in which the plane designer must conform to the design of the engine. On the other hand, the engine designer must have a comprehensive knowledge of plane construction and design for various reasons.

In the first place there are various engine accessories such as the carbureter, the ignition system, oil and water pumps, spark plugs, etc. which must be readily accessible for inspection and replacement in the finished plane. There are certain locations where inspection openings can be provided in the fuselage or the engine cowling without impairing the strength of the fuselage structure. It is obvious that the engine should be designed so that these accessories will be at points where they can be reached conveniently through these openings.

Then again there is the question of fire protection. There is no hazard in flying that can be compared to the danger of fire. The plane itself can be built with so high a factor of safety that it will be absolutely safe against collapse in the air no matter what strain it may have to meet. But if the engine has not been designed and installed with a view to eliminating the fire hazard completely, the plane cannot be considered 100 per cent safe no matter how experienced or capable the pilot may be.

The requirements for safety against fire are relatively simple and easy to comply with. The carbureter air intake, through which the engine is likely to back-fire occasionally, must be led outside of the engine cowling and well away from any inflammable material.

The best location is undoubtedly underneath the engine so that in the event of the carbureter flooding, all gasoline will drain harmlessly away. In the new aircraft engines designed by Packard since the war, this point was carefully considered in the original design and the whole engine was laid out around a carbureter location chosen to eliminate the fire hazard. The carbureter is bolted to the lower half of the crankcase to communicate with the intake manifolds above.

With this arrangement, other advantages are secured simultaneously such as the ability to use gravity feed for the gasoline feed of the carbureter. This gives safety as compared with any kind of a pressure system, as well as an extremely accessible location for inspection or adjustment on the ground.

There are other very necessary precautions to be taken against fire but these are mostly details to be observed in installing the engine in the plane. For instance, all electric wiring must be run in conduits and securely fastened against vibration. Gasoline piping must be carefully guarded against chafing and rubber hose connections should be used at strategic points where the vibration might ultimately cause a break if a solid connection were used.

The characteristics of the engine in regard to vibration have an important bearing on the design of engine mounting and this must be taken into consideration at any early stage in designing the plane. There is a great deal of difference in the smoothness of operation of various types of engines. The 12-cylinder V-type engines, for example, are notably smooth and free from vibration while 4-cylinder vertical engines are practically excluded from aircraft use because of their inherent vibration. Again a rotary or radial engine will require an entirely different type of mounting from an engine of the cylinder-in-line type. This shows how the design of the engine mounting will depend upon the type of engine and the whole fuselage structure may be affected by this fact.

It should be apparent that the plane designer is badly handicapped unless he has the fullest possible knowledge of the engine or engines to be installed. While he is not particularly interested in such details as the methods of operating the valves or lubricating certain parts of the engine, he should be entirely familiar with all the operating characteristics of the engine. He should know its power output at various speeds, its fuel and oil consumption under different speeds and loads, its intensity and direction of its vibration at critical engine speeds, etc.

Furthermore, the plane designer must have complete information regarding the weight, the location of the center of gravity, the locations for fuel, oil and water connections and the necessary clearances between the engine and the walls of the fuselage for making inspections and adjustments of the engine.

Finally, the responsibility for providing adequate radiator capacity for the engine, if it is of the water-cooled type, rests largely on the airplane designer, since he is presumed to be familiar with the work that the engine must do in flying the plane and the danger of overheating that it will meet.

R-34 Crew Receives Navy Cross

The Secretary of the Navy has approved a recommendation to award the Navy Cross to the members of the British Airship R-34, which made her memorable flight across the Atlantic Ocean in July 1919. This was the first flight made across the Atlantic from East to West, it was the first aerial round trip over the Atlantic; and it was the first dirigible to make the voyage between America and Europe.

It is interesting to note that the great American airship now building, the ZR-2, formerly the R-38, will have a capacity greater than the R-34 by approximately 700,000 cu. ft. and a cruising radius of 8,000 miles, nearly double that of the R-34.

The names of the crew of the R-34 receiving the Navy Cross are as follows:

Major G. H. Scott, commander; Brig.-Gen. E. M. Maitland, Major G. G. Cooke, Major J. E. M. Pritchard; Capt. G. S. Greenland; Lieut. H. S. Luck, Lieut. I. D. Shotter; Lieut. G. Harris; Lieut. R. F. Durant.

Wireless Operators: H. R. Powell, corporal; W. E. Edwards.

Engineers: W. R. Gent, flight sergt., R. W. Ripley, flight sergt., N. A. Scull, flight sergt., T. Thirlwell, sergt., H. G. Evenden, sergt., J. Gray, corp.; G. Graham, R. Parker, J. Northeast, P. Cross, corp., J. Mort.

Relief Altitude and Direction Pilot: Lieut.-Comdr. Z. Lansdowne, U.S.N.

Riggers: W. R. Mayes, coxswain, W. J. Robinson, flight sergt., A. M. Watson, sergt.; F. Smith, corp. rigger, W. J. Burgess, corp. rigger; F. P. Browdie, rigger; J. N. Forteath, rigger.

New Spanish Aerial Routes

According to a statement made in Madrid, new aerial post routes will be created between the following towns: Seville and Larache, Barcelona and Palma-de-Mallorca, and Malaga and Melilla.

The aerodromes to be used at each point will be those belonging to military aeronautics. On the first of these routes there will be two intermediate landing grounds at Lebrija and Vejer-de-la-Frontera.

Ten airplanes will be employed on the first service which will be daily.

The aerial line from Barcelona to Palma opened on March 18, has not yet become a regular service.

Aviation Committee, American Bar Association

The Committee on the Law of Aviation of the American Bar Association has made its report and looks forward to securing much valuable information during the ensuing year. This Committee organized upon the appointment of its members by the president of the association. Its membership is as follows: Charles A. Boston, New York, *chairman*, Orrin N. Carter, Chicago, Ill., William P. Bynum, Greensboro, N. C., George O. Bogert, Ithaca, N. Y., and William P. McCracken, Chicago, Ill.

Before the selection of members of the Committee, but with knowledge that the Committee had been authorized, the governors of the Aero Club of America designated a Committee to cooperate. The members of this Committee are as follows: William W. Miller, Stephen H. Philbin, Philip A. Carroll, W. Benton Crisp and Col. Arthur O'Brien.

The Committee has been in correspondence with many of the organizations interested in aviation and has received much assistance from various government departments which have had the law of aviation under consideration.

Consideration has been given to the letter of William V. Rooker, of Indianapolis on the Jurisprudence of the Atmosphere, which was circulated among the members of the Conference of Delegates at St. Louis last summer, and which contains information and endeavors to classify powers, (1), as between the United States and foreign governments; (2), as between the United States and the several states; (3), as between the political and judicial departments of the United States; (4), as between the state and the owner of land; (5), finally, the nature of such jurisprudence.

The Conference of Commissions on Uniform State Laws at its meeting in August, 1920, adopted the following resolution:

"The whole world has come to a realization of the fact that aviation is practical and not a mere art or fad for pleasure and profit in exhibition flying, for many states in the Union now have scores of aviators constantly flying from state to state carrying commerce betwen the states, which aviation needs regulation, so your Committee recommends the appointment of a special committee to investigate this subject and report as soon as practical a uniform aviation law."

The members of the Committee of the Commissioners are: John Hinkley, Baltimore, Md., Charles V. Imley, Washington, D. C., Thomas J. Brooks, Bedford, Ind., N. E. Corthell, Laramie, Wyo., George G. Bogert, Ithaca, N. Y., A. T. Stovall, Oklona, Miss. and George B. Young, Montpelier, Vt.

Mr. Hinkley has indicated that he considers the scope of the two committees is different, in that the Bar Association Committee as he assumes is authorized to consider particularly the interstate and international features of the question, while his committee is limited to matters of strictly state regulation.

A communication was received from the Judge Advocate General giving full information respecting action on the regulation of air navigation in the United States, from which it appears that legislation has been passed already in Hawaii, California, Massachusetts, Michigan, Texas, Washington and Wisconsin, while New York now permits aircraft insurance. The Judge Advocate furnished an informative list of articles on the subject, not appearing in the other lists furnished from other sources. It appears that his office has not yet rendered any opinion on the subject, but that some study has been devoted to it and some observations have been made.

Among the suggestions made to the Committee is that from the experience in aviation insurance in many countries there arises a conviction that it is of vital importance to cover as big a territory as possible by the same regulations, and this imperatively calls for Federal laws and Federal supervision, and any legislation by single states, as effective and well-devised as it may be, will ultimately be detrimental to a branch of transportation which by its very nature is successfully possible only if employed over great distances; that such legislation may concern the ship, its cargo, its passengers, ports of flying, the routes and the transportation company itself, and one of the most important points is the person of the pilot.

Information that the Lloyds have an Aviation Committee, and that a bill has been brought before the British Parliament by the British Civil Control Department for Air, intended to give that Department fuller powers by extending very considerably the British Air Navigation Acts of 1911 to 1919.

The foreign manager of the International Fire and Marine Agency Corp. in New York has kindly volunteered to confer with his company's London office and secure copies of the British air navigation acts, and the new bill now pending in Parliament. It is suggested that this legislation is doubtless the most up to date and complete now in existence, and that its study will probably convey considerable indication of points worthy the attention and supervision of a government.

The resume of observations accompanying the letter of the Advocate General deals with the constitutionality of Federal legislation and legislation regulating air navigation, chiefly with analogies of decided cases and legislation in somewhat kindred fields; it deals with air navigation as commerce, with the analogy of the migratory bird acts; with the analogy to railroad traffic, with the analogy to radio-telegraphy, with the desirability for uniform legislation; with the absolute necessity for uniformity in the protection of interstate and foreign air navigation, and the probable effects of such legislation over intrastate air navigation with the analogy of the regulation of private pleasure water craft; with the analogy between navigable air and navigable water; with the possibility of conflict between state and federal claims, in that the Constitution does not grant the same authority over navigable air as over navigable water, with the embarrassment caused by the common law doctrine of *cujus est solum, ejus est usque ad coelum*, and with the denial of the existence of this doctrine, or its limitation by altitude, with the subjection of aircraft to National regulation, and by reason of their relation to the safety of other craft over which the National government would undoubtedly have jurisdiction, the incidental effect of the exercise of Congressional power to see that interstate commerce may be conducted upon fair terms and without molestation and hindrance; with the effect of treaties as extending the national power to deal with the subject covered by the treaty, with the effect of action by Congress over matters clearly within its jurisdiction, but incidentally also within the jurisdiction of the state police power, or other power, with the difference between the exercise by Congress of power in anticipation of a treaty, and of power in fulfillment of a treaty.

The chairman of the Committee, Charles A. Boston, 24 Broad Street, New York, requests any information on the subject of the law of aviation be sent to him.

Land Mooring of German Airship M-4

Government Agencies and Aeronautics

Many governmental agencies cooperated during the war and at present are working on the development of aeronautics along experimental, military, naval, civil and scientific lines.

The Bureau of Standards, Washington, a national institution for scientific research, has a number of laboratories, embracing the field of physics, chemistry and engineering, utilized for the study of aerodynamical physics, of aircraft instruments, aero engines, aerial photographic apparatus, aircraft metallurgy and materials.

The standardization of specifications for raw materials, for parts, inspection, etc., was inaugurated by the International Aircraft Standards Board, Washington.

Fuel is one of the problems in aeronautics. The Bureau of Mines, Washington, is concerned with such investigation. Flares and other signalling devices, supply of liquid oxygen, perfection of light alloys and the development of the non-inflammable light gas helium for airships and balloons have been worked upon by this bureau.

The Forest Products Laboratory, Madison, Wis., has to do with aircraft woods, their growth, treatment, and physical characteristics.

The National Advisory Committee for Aeronautics, Washington, was established by Congress in 1915. It has twelve members appointed by the President, representing several government departments, and including five from private life. Its function is to advise in determining the problems in aeronautics to be experimentally attacked, and to coordinate, among the various governmental and private agencies, the research and experimental work involved. This is accomplished through the instrumentality of sub-committees, on each of which the Army, the Navy, the Bureau of Standards, and other agencies have specially appointed representatives. The National Advisory Committee for Aeronautics conducts, in its own laboratories at Langley Field, Va., such scientific research on fundamental or purely theoretical problems as may be approved by the sub-committees mentioned.

The Committee has an office of aeronautical intelligence, for the collection, analysis, classification and dissemination of scientific and technical data on aeronautics received from all agencies in this country and from the principal agencies abroad. To aid in the collection of such material abroad it has established a permanent office in Paris. The Committee examines inventions in aeronautics, makes special tests of instruments in its laboratories for private individuals at cost, and gives its advice to any one engaged in the study of definite aeronautical problems. The facilities of the Bureau of Standards for the conduct of aeronautical research have been placed at the disposal of this Committee, and of the Army and Navy. Special problems are placed with the Bureau of Standards on research authorizations approved by the Executive Committee of the N.A.C.A.

The National Research Council, Washington, established in 1918, is another governmental organization cooperating with other agencies in aeronautics. Among the problems that have been dealt with by this body are airplane instruments, bomb sight, bomb trajectory, and stabilization problems, photographic signalling, detection, airplane, balloon, ordnance and miscellaneous problems.

The Navy operates an aerodynamic laboratory at the Washington Navy Yard, and conducts tests on aircraft engines and models in its wind tunnel.

The Army's Air Service experimental laboratory, at McCook Field, Dayton, Ohio is a most complete plant for the experimenting with and testing of all manner of aircraft, engines and accessories.

The Post Office Department, Washington, has done directly or has instituted research work along lines affecting operation of aerial mail service.

The Weather Bureau, in Washington and principal cities, is cooperating in aeronautics in the exploration of the air and in the furnishing of forecasts in advance of regular or special voyages.

The Forest Service, the Bureau of Fisheries and the Bureau of Entomology, all in Washington, are among the other governmental departments which are utilizing aircraft in their application to the work of these agencies.

Civil Agencies

Massachusetts Institute of Technology, Leland Stanford Jr. University, Throop Institute of Technology and State College of Washington operate laboratories in which tests of aeronautic devices may be made. Many other engineering schools of aeronautics and others are contemplating the establishment of a curriculum.

Curtiss Engineering Corp. conducts a laboratory for public use and acts in a consulting capacity
and universities have inaugurated courses on various phases

Across the United States in a Day

The route for the transcontinental one day flight to take place on February 22 has been selected. The route chosen extends between Florida and Southern California. The starting point in Florida will be Pablo Beach, Jacksonville, and the starting point in Southern California will be San Diego. The former point is within the Eighth Corps Area and the latter point is within the Ninth Corps Area. The distance flown will be 2079 miles. There will be two participants in this flight. Lieut. Alexander Pearson, Jr., will take off from Pablo Beach, Fla., making the flight in three hops; from Jacksonville, Fla., to Ellington Field, Houston, Tex., 804 miles; from Ellington Field to El Paso, Tex., 660 miles; from El Paso to Rockwell Field, San Diego, Cal., 615 miles. The participant from San Diego, whose name has not been announced, will reverse this schedule, making the flight on the same day.

It is believed that this flight will produce records of performance which will be of extreme interest in the furtherance of both commercial and military aeronautics and will be the first in history in which the United States has been completely traversed in so short a period of time.

Advertisements Appearing in a Paris Daily

New York, Boston, Chicago, Atlanta, Denver, San Francisco—When?

Requirements of the Commercial Airplane

By William B. Stout

War type aircraft demanded design for fighting purposes, with no respect to either cost or safety. The commercial airplane, on the contrary, can only exist by reason of the *safety* of its transportation. Cost in any business enterprise is only secondary to safety, and if the airplane would be made a business vehicle, and air travel a commercial thing, then the first steps to be taken by engineers and those working with airplanes to develop such commercial travel must be along these lines which will bring, first; safety, and second, lower cost.

Safety in aircraft comes under two major divisions, first, safety on land; second, safety in the air.

Safety on land includes the period of landing with all of its attending problems, safety at rest during the storage period, and safety in taking off, with period of working over the ground and taking into the air until such point of travel is reached that the pilot is sure he is away on his journey.

Safety in the air has, first, relation to structural strength, second, to control and the controllability of the design, and, third, freedom from fire danger.

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These divisions, in their broadest sense, cover practically every angle relating to safety in air travel, and a study of each of the six divisions mentioned, with analysis as to how maximum results can be obtained in each division, cannot help but build up in one's mind a picture of a general line of development, so far more or less neglected, which must lead to rational advancement in commercial aircraft design.

Cost in airplane construction and operation first divides—as did safety—into two divisions; on land, and in the air, both divisions, however, having attached to them a certain amount of fixed costs included in what is ordinarily known as "overhead".

The cost of an airplane on land is, first, that of storage, second, repair and maintenance, and third, fixed charges of overhead. The cost in the air is that of fuel and oil, that of navigation, and also fixed charges of depreciation, insurance, etc.

The analysis of these items in connection with aircraft—and this, so far as commercial operation is concerned, is of the most vital importance—will again give a new picture of aircraft design possibilities, and of types of aircraft to fit the requirements of the analysis.

These items of safety and cost are so closely interwoven that one can hardly think of one without the other. Safety determines whether the public will use aircraft, cost determines whether one can afford to carry the public in aircraft, no matter what their demands. Safety must be had before beginnings can be made, but airplanes cannot be used successfully in commercial work until the costs are gotten down to a figure reasonably consistent per ton-hour-mile with other means of more or less efficient transportation.

This discussion is not one of the problems of navigation, of piloting, nor of the opportunities of business aircraft. It is meant to present a structural engineering analysis of the plane itself, and what it can and must be for this work.

As a measure of continued picture, it would be well to analyze the divisions of safety and cost which have been made, and to suggest with each the type of structure, of known performance, which is already available to use in getting the results which each particular item shows to be a requisite. The first item mentioned is that of landing safety, and it is a fact that 75 per cent of the danger of aircraft is here.

From the standpoint of the machine itself, landing security depends upon a number of things, of which the slowness of speed is but a minor item. It is very easy in an airplane to obtain slow speed in landing, but beyond certain limits, very definite liabilities accrue which make slow speed a danger rather than a safety factor.

The speed at which an airplane lands, or can land, depends at present upon its wing loading, that is, the amount of weight which a square foot of wing must carry. A wing carrying 12 pounds per square foot will land at approximately a mile a minute; a wing with a 7-pound load will land at about 45 miles per hour, while a 3-pound load would allow of a 30-mile landing. A plane which could land at 30 miles per hour, however, would be entirely carried away by a 30-mile gust of wind, so that in landing a machine of light wing loading, there is danger of air currents. A wing load of under 5 pounds is dangerous to land from this point of view.

Each wing curve has its maximum lift angle in the neighborhood of 14 to 16 degrees, and planes should be so designed that when a perfect three-point landing is made with the two front wheels and the rear skid at the same time, the wings at this 16 degree angle, or whatever may be that of a maximum lift. This not only gives the slowest possible landing with that type, but adds greatly to the wind resistance which will slow the ship up after it touches the ground.

There are a number of mechanical features which also add to safety. Undoubtedly, the lighter a ship, the less inertia it will have, and the easier the problems of stopping it should be—bearing in mind the problem of wing loading.

If the landing is made on rough ground, the flexibility of the landing chassis is very important, and many mistakes have been made in chassis design which have only lately been corrected. Shocks to the chassis in landing come from all directions—forward, backward and sideways—and must be absorbed as quickly as possible. In early ships, axles were mounted in guides so that shocks would be taken vertically, but in later constructions, shock absorbing means are attached to the landing gear struts on wheels and range of action almost equal to their own diameter, and with these planes, landings can be made on surprisingly rough ground without breakage to the chassis.

The final item of landing safety is that of power reliability. It is necessary very often for the pilot to fly around a field and take a look at it at a low altitude before he lands, but even after he has tried for a landing and sees his mistake, to take off again to make another trial. This requires absolute dependability on the power plant. I am glad to say that this item is being well taken care of.

This analysis practically completes the requirements of landing safety, and one can see at once the amount of research that still remains to be done along this line.

Safety at rest is a minor requirement, and can be had either by proper hangar facilities, or by weatherproof and thief-proof constructions that can be left out in a field and anchored down against the contingency of storm or wind.

Safety in taking off brings in other items, but this is not nearly the important crisis that landing is. One cannot always choose the ground on which he is to land. He can very frequently choose the position from which he takes off. Safety in taking off depends, first; on the dependability of the power and the number of pounds per horsepower of engine which this power has to lift. In other words, the climbing angle. A plane that is slow in climb has a hard time taking off in a small field.

This item of climbing and the related one of acceleration in getting away, which is due to the same power load, offer big items of safety in the take off. Once off, the reliability of the power to carry one to a safe altitude before requiring a glide, is a secondary but important item.

The discussion so far, therefore, pictures the items giving safety on land, and as stated before, these are more than 75 per cent of the entire risk features of airplane design.

As previously outlined, safety in the air depends on structure, controllability and freedom from fire risk. There is little trouble nowadays in designing a proper structure, although even today the greatest problem of the airplane designer is to get a combination of proper structure with maximum aerodynamics.

It is, of course, entirely necessary that a plane be strong enough to hold together under all the conditions of flying and landing. No matter what its aerodynamics or speed charac-

teristics or performance possibilities may be, if it is going to break in the air, it is a useless ship

Safety of structure has come by a combination of engineering analysis and experience with air stresses, until now, through forms of sand loading through which planes are put, preliminary to their flights, one knows very well what the structural strength of a plane is before he puts it into the air The general arrangement of the design first determines structural strength of the plane, and these structural arrangements are being improved and developed continuously by various manufacturers.

Choice of material is also an important factor, although this has been over-done in Government planes, and faulty mechanical arrangements they have tried to make right by super-alloy steels and fussy production methods, rather than by perfect mechanical analysis before the structures were built

The successful commercial ship must be made of so-called "garden variety" of material, available at any garage or workshop, with no features of workmanship involved which cannot be duplicated in the ordinary shop It is very probable that mild carbon steels and duralumin will replace alloys for many fittings, and tubing and rods take the place of expensive cables and turnbuckles, but how this is to be accomplished will appear in a later analysis

All airplanes are designed with certain factors of safety or margins of strength In commercial work, these factors of safety are readily obtainable which are more than sufficient under all usual conditions of flying, but should, nevertheless, be held to by designers ready for those emergencies of flying and overloading which occasionally come up There is small excuse for structural failure in any modern developed ship Experimental planes can be often thoroughly analyzed and tested before flying, so far as structure is concerned, so that safety in test flying, even, has become more evident

Safety of control is the next important item, once one has gotten off the earth The first requirement is a knowledge of the size of all control surfaces as related to the center of pressure of the wing surfaces and the lever arms on which they will operate from that center All of these factors are determined through the use of a small model in a wind tunnel, as fairly accurate results can be had from this model, and one can determine just what is to be expected from a full-size airplane It is still an open question, however, whether the air speeds in modern tunnels can give proper readings for the new thick wing sections at high speeds, and it is probable that developments along this line will come. The results to date, however, have been accurate enough so that the planes designed from the present methods have been successful and safe to fly

To give a permanent fore-and-aft dihedral, the mechanical arrangement of the controls can be of various forms, but the strength of all control operating members should be such as to stand the maximum strength of the pilot pulling against the controls in any direction.

A large part of the control is dependent upon the power plant, and it is well to have the rear controls located within the slip stream of the propeller, so that in an emergency, the engine may be switched on for extra effect on the elevators or rudder.

Power dependability is also important as an addition to control, in coming into or taking off of a field, so that the acceleration and climbing power of the plane is always an element of control safety Overloaded machines cannot be as safe as underloaded

Much has been said about fire danger in airplanes, and many pilots, neglecting the simplest of fire preventatives, have come to grief. Part of this has been due to lack of foresight in the designer by allowing places to exist around the engine where oil and fuel might accumulate and invite conflagration, but a large part is sheer neglect on the part of airplane owners and operators.

The first thing to watch is the installation of the engine, the location of the carbureter outlet, etc. In all airplanes, this outlet should be arranged so that a back fire from the engine carries entirely outside the plane and all drippings from the airplane also carry away completely Gasoline lines leading to the carbureter should not run from the tank directly down to this fire center, but should have loops to prevent leakage running down the pipe, flexible connections to prevent breakage, and extra care should be taken in the construction of all connections and fittings The tanks should be installed at a distance from the engine. The last part of the line to the carburetor should point upward from the plane's normal gliding angle, so that even when gliding down the gasoline will not run down the pipe to the carburetor, but will drip off and out of the plane before it reaches it.

Pressure feeds should never be used on an airplane on account of danger in a crash; vacuum feed is hardly desirable; gravity feed from a small tank is at present about as good a type as is known, provided the preventatives mentioned before are made use of.

The engine compartment should also be separated from the passenger compartment by a fire wall having a minimum number of openings—in fact, the British specify that there should be no openings in this fire wall

The cleaner the engine and the more accessible, the less fire danger there will be, and it is advisable that the engine be installed in such a manner, if possible, that all outer cowling may be removed from all around the engine, not only on account of accessibility in case of repair, but to prevent the danger of oil accumulation and to enable one to clean the inside of the engine and gasoline compartment frequently and thoroughly

Special attention should be given to all ignition and electrical equipment so that no sparks may be caused close to gasoline or oil drippings, or where gas is likely to accumulate.

In ships with internally-trussed wings or planes carrying the tanks in the wings, the surfaces around the tank equipment should be ventilated so that a draft of air continuously prevents accumulation of excessive gas, with the accompanying danger of the explosion of the complete ship should spark occur or someone light a match This item of wing ventilation is important

Properly installed, there should be no real fire danger, and this feature and the methods of preventing fire are emphasized only because it is so important an item that this be done right. Knowing the danger should fire occur, there is small excuse for sloppy engine installation Many engines, otherwise good for aeronautical work, are very faulty from a standpoint of carburetor location and fire danger, and this point should be more carefully looked into than any other item in selecting an engine for a plane, especially for commercial airplane work

Given a proper ship, designed along the lines which visualize from the foregoing analysis, the operation of an airplane in commercial work should be attended with greater safety per mile than any other means of fast transportation, and a reliability which already has been proved to be better than that of the railroads, under the most adverse of flying and weather conditions

The airplane has already proved itself to be ready for the commercial transportation field It but remains for the engineer to devise that type of plane, containing these items of safety, which will, at the same time, gather unto itself those items which will bring a minimum cost of operation and maintenance, that profit may be made from the sales and operation of this craft, and that a real industry may be formed

Control of Flights in Army Aircraft

The attention of commanding officers of Army Air Service activities has been directed to the fact that Army regulations give to the Chief of Air Service the authority to prescribe regulations governing flights in Air Service equipment for other than training or war purposes. Department or corps area commanders may properly issue such additional instruction on the subject as may be dictated by the conditions under which tactical Air Service units under their command may be serving, providing these additional instructions conform to and do not conflict with the regulations issued by the Chief of Air Service.

The department or corps area Air Service officer, in his dual capacity as a staff officer of the department or corps area commander and as the representative of the Chief of Air Service, is charged with the duty of calling the commander's attention to any conflict between local orders and Army regulations or orders properly issued by the Chief of Air Service

Design of Recording Wind Tunnel Balances

By F. H. Norton,

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The following description of the design of a recording wind tunnel balance was prepared at the Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics, as the use of such a balance will greatly increase the efficiency of operation of a wind tunnel by increasing the capacity of the wind tunnel with a decrease in personnel

Wind tunnel tests may be divided into two classes commercial testing, where great accuracy is not important, but where rapidity of testing a more or less standard type of model is essential, and scientific work where the tests are of various kinds and accuracy is more important than speed A balance for the first class of work used not be universal, but it should have a means for recording lift, drag and pitching moment, preferably plotting them continuously against angle of incidence.

The second class of work demands a balance capable of supporting conveniently any type of model, and should hold them rigidly even at high speeds All three moments and three forces on the model should if possible be recorded simultaneously and plotted either against angle of incidence or angle of yaw It might seem that such an elaborate recording mechanism would be too great an expense, but when it is realized that it would save the time of three men, and would at least double the capacity of the tunnel there will be no doubt of its advantage.

The qualities desired in a scientific balance may be summarized as follows:

1. It should weigh all forces and moments simultaneously
2. It should allow an incidence change through 360 deg.
3. It should allow the use of any type of spindle or wire support
4. It should allow a yaw of 20 deg
5. Forces and moments should be continuously recorded against angle of incidence.
6. Models should be easy to install and adjust.
7. Computations should be reduced to a minimum.
8. The weighing mechanism should be simple and positive.
9. The balance should be stiff enough to use at high speeds.
10. The balance should be simple and inexpensive to construct.

In order to choose the type of balance best suited for scientific work, the characteristics of the most successful balances will be considered.

The N. P. L. type of balance (Fig 1) allows a ready adjustment of the angle of incidence, and the lift, drag and moment readings are conveniently read. Its greatest disadvantages are the difficulty of supporting thin ended wings, or any model at high speed, and as moments and not forces are read spindle corrections are difficult to make. It is also impossible to simultaneously read all forces and moments.

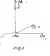


Fig 1

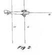
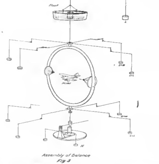


Fig 2



Assembly of Balance
Fig 3

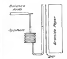


Fig. 4

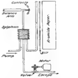


Fig 5

The wire balance as used at Goettingen (Fig 2) has the advantage of being inexpensive and simple, but it does not allow large angular changes, and it is not universal

The new Washington Navy Yard balance, working on the parallelogram principle, is the highest development in wind tunnel balances at the present time, and although it is self-balancing, it is not recording. The range of the angle of incidence is from +90 deg to —90 deg with the usual set-up, and +360 deg. by a special set-up

After a careful study of the preceding types of balances had been made, it was decided that the most satisfactory arrangement would be a rigid ring completely surrounding the tunnel or wind stream, so that the model could be supported from it by wires or any arrangement of spindles. The forces and moments acting on this ring can then be recorded by suitable weighing apparatus.

A diagrammatic sketch for a balance of this type is shown in Fig. 3. The weight of the balance is supported on a long tor-

sion wire, with a mercury or water float to carry most of the load, and the lift on the model is measured by a simple lever The drag and pitching moment are measured by two arms connected to ball bearings at the upper and lower side of the ring The difference of the weighings give the moment and their sum the drag In the same way the cross-wind force and rolling moment are measured on two similar arms at right angles to the air stream The yawing moment is measured at the bottom of the balance through a flexible joint. All weighing arms have corresponding counter weight arms to keep the systems in tension, and as the movement of the arms is restricted to a very small amount, the problem of stability does not arise.

The methods available for recording the forces on the arms consist of the following

1 A motor driven sliding weight, in the manner of a test-

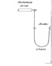


Fig. 6

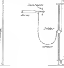


Fig. 7

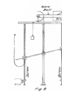


Fig 8

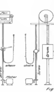


Fig 9

ing machine. This method requires the mounting of the recording drum on the balance arm, thus making it impossible to record the sum or difference of two weighings which, as will be shown later, is quite essential.

2. A spring or Toledo type of balance has been suggested but the deflection required is much too large, as the arm should not have a movement of more than a few thousandths of an inch, or there will be interference between the different weighings, and the stability would have a serious effect.

3 The forces could be recorded by a mercury filled syphon as shown in Fig 4 The pressure is recorded by the height of a mercury column, which covers a slit before a moving strip of bromide paper Let us assume that the maximum pressure to be read is one kilo, with an accuracy of 1 gram. As the height of the mercury could be recorded to 1/10 mm. the total height would be 10 cm. Assuming that the area of the mercury column could be made as small as 4 sq. mm., the area of the syphon would be 7.4 sq. cm. and its maximum deflection would be .5 mm. While this deflection would not be objectionable on some arms, it would be very simple and positive, but there would be considerable temperature correction which would be objectionable for recording work.

4 A more complicated fluid device is shown in Fig. 5 which will keep the deflection down to a very small value. The force on the arm is simply balanced by the fluid pressure in a syphon or diaphragm. The fluid is pumped through the chamber and its escape is regulated by an electrically controlled valve, operated by contacts on the balance arm, and the pressure in the chamber is recorded in the same way as before This device would require considerable developing and would be rather expensive to construct

5 The simplest and most satisfactory device is probably an adjustable chain weight as used in chemical balances, (Fig. 6) This is simple, accurate and allows the recording pen to be easily attached This method has been tested out and it is found that machine-made commercial chain is sufficiently uniform to give good results.

In Fig 7 is shown a method of using this chain weight on a recording balance One end of the chain is attached to the balance arm and the other to a slider driven up or down by a screw which is operated by a reversible electric motor The motor receives its current through the contact points on the balance arm so that it will automatically balance the force A pen is connected to the slider by a steel tape in order to reduce the motion, and this pen records the force on a drum which is driven synchronously with the model It is possible to use a heavy enough chain to take care of all ordinary forces, but when runs are made at high speed, it will be necessary to add unit weights, and allow the instrument to rebalance.

As it is very desirable to plot actual forces and moments, the former are obtained by mounting a pen on an equalizing bar so that the sum of the forces are recorded (Fig 8), and the latter by mounting the drum on one slider and the pen on the other (Fig 9) so that the difference of the forces are given.

In conclusion, the proposed type of balance will support the model rigidly in a variety of ways, will make a complete test without attention, and will plot the results so that all computation are avoided While this balance is more expensive to construct than the usual type, it would certainly pay for itself in a short time, by the large volume of work it could turn out and by the reduction in the wind tunnel pay roll

An Ingenious Handling Truck

One of the production problems in all industries is the movement of material in the shop. This is usually done by some form of truck. An interesting and ingenious solution of the problem is presented by the "Transveyor" manufactured by the Cowan Truck Co This is a three wheeled truck designed to move skid platforms by being run under them and then lifting them a short distance above the floor By this means one truck unit can handle many different platforms An example of its use is represented by the shops of an engine manufacturer The parts are loaded on a platform in the foundry and taken by a transveyor truck to the machines There the parts are either piled on the same truck as they are finished or are piled on another skid platform for the truck to move on to the next operation. Each truck can be continually in use instead of having to wait until unloaded. The trucks are designed to carry 5000 lb and are made of steel in various sizes and height of lift.

Corresponding Army, Navy and R. A. F. Ranks

The following list gives the corresponding ranks of the Royal Air Force and the Army and Navy of the United States. It is significant to note that the British Marshall of the Air outranks the head of the American Army, General Pershing

U. S. ARMY	U. S. NAVY	ROYAL AIR FORCE
	Admiral of the Fleet	Marshall of the Air
General	Admiral	Air Chief Marshall
Lieutenant General	Vice Admiral	Air Marshall
Major General	Rear Admiral	Air Vice Marshall
Brigadier General		Air Commodore
Colonel	Captain	Group Captain
Lieutenant Colonel	Commander	Wing Commander
Major	Lieutenant Commander	Squadron Leader
Captain	Lieutenant	Flight Lieutenant
First Lieutenant	Lieutenant Jun Grade	Flying Officer
Second Lieutenant	Ensign	Pilot Officer

Testing Lubricating Oils*

Classification of Lubricating Oils

Lubricating oils are classified according to Archbutt and Deeley as follows·

A. Mineral oils.
B Fixed oils
C Blown or thickened oils.
D. Rosin oils
E Lubricants containing soap Greases.
F Deflocculated graphite—"Aquadag" and "Oildag".

Mineral Oils.—The manufacture of lubricating oils from crude petroleum and shale oil is a branch of a very extensive industry The great variety of hydrocarbons of which the crude oils are composed affords material for the manufacture of numerous products. The lightest and most volatile hydrocarbons compose crude naphtha, from which rhigolene, gasoline, petrol, or motor spirit, and similar products are obtained. These liquids, which are devoid of all lubricating property, form highly volatile and inflammable "spirits," used for driving motors, dry-cleaning, making air gas, carbureting coal gas, and for solvent and other purposes. Of these products, the motor spirit is now by far the most important commercially Hydrocarbons of higher boiling point and specific gravity, which are still too fluid and volatile to be used for lubricating, compose the illuminating oils of commerce, known as kerosene, petroleum, paraffin oil, etc. The heaviest and least volatile hydrocarbons are alone used for the manufacture of lubricating oils, paraffin wax and vaseline The refiner's business is to separate the various products from the crude oil and purify them for use, and this is done by distillation and chemical treatment.

The value of distillation depends upon the fact that the different constituents of the crude oil boil and volatilize at different temperature, the naphtha coming over first, then the illuminating oils, then some intermediate oils used for gas-making, or destructively distilled so as to increase the quantity of illuminating oil, leaving the heaviest hydrocarbons as a residue in the still, unless the distillation is carried to dryness, in which case coke would be the resulting product. By separate fractional distillation, the naphtha is subsequently split up into motor spirit, gasoline, etc., and the residuum into lubricating oils of various grades, paraffin wax, and asphalt or coke

Fixed Oils—Fixed oils, so-called because they are not volatile without decomposition, are found ready formed in certain tissues of animals and plants. Fixed oils include such oils as castor, rape, lard, cottonseed, and whale

Blown or Thickened Oils.—The blown oils used for lubrication are usually rape or cotton seed oils which have been artificially thickened by a process consisting in forcing a current of air through the heated oil

Rosin Oils—Rosin oil is obtained from the destructive distillation of common rosin

Lubricants Containing Soap, Greases.—Such lubricants are artificially thickened by dissolving soap in mineral oils. Of these lubricants or greases the principal ones are cup and engine greases.

Deflocculated Graphite—"Aquadag" and "Oildag"—A paste of deflocculated graphite and water, known as "Aquadag," is added to lubricating oil in a suitable mixing machine The water is gradually thrown out, leaving the deflocculated graphite in a paste form with the oil, known in commerce as "Oildag". "Oildag" added to mineral lubricating oil increases the lubricating value of the oil under conditions where solid friction exists.

Tests for Lubricating Oils

The tests on lubricating oils include:

A Gravity, Baume, at 60 deg. F.
B Flash, Cleveland open cup.
C Fire, Cleveland open cup.
D Viscosity, Saybolt Universal viscosimeter, at 100 deg., 150 deg., and 212 deg F.
E Pour test, as described below and also in Specification No. 3525
F Acid

Specific Gravity

Apparatus—Set of hydrometers.

Method.—The hydrometers as supplied in the field testing outfit are marked with the specific gravity direct

Since all specific gravities are comparable at 60 deg F, the results should be reported in degrees Baume at 60 deg F

Flash and Fire Test

The flash point is the degree of temperature at which ignitable volatile vapors are given off by the oil, producing a flash when brought in contact with a small flame. The fire test is a continuation of the flash test until the oil permanently ignites.

Apparatus.—The apparatus for the flash and fire test consists of the following

A. Cleveland open-cup tester, as recommended by the Bureau of Mines
B Alcohol lamp or gas burner
C Thermometer with range to 600 deg. F., corrected for bulb immersion.
D Wax tapers or gas jet.

Method—This test shall be made in the Cleveland open-cup tester, the apparatus being used without any bath or outer cup surrounding the oil cup The oil cup should have two marks on the inside—the first, one-quarter inch below the top, and the second three-eights inch below, the first to be used when testing oils with a flash point below 425 deg F, and the second when testing oils with a flash point at or above 425 deg. F The clean oil cup should be inserted into the tripod ring, which must be level, and the cup filled to the proper mark with the oil to be tested Care should be exercised not to spill any oil on the sides or top of the cup, and if this accident should happen, all such oil must be carefully removed.

A "bulb immersion" thermometer should then be inserted into the oil, and suspended from a suitable support. The bulb of the thermometer should be three-eights to five-eights inch in length. During the test the bulb must be fully covered by the oil and the bottom of the thermometer must not be less than one-fourth inch from the bottom of the cup The thermometer must be suspended in the oil midway between the center and inside edge of the cup The alcohol or gas burner is then placed under the oil cup so as to heat it uniformly The oil may be heated rapidly at first, but the rate of heating should be 8 deg to 10 deg. F. (5 deg. C) per minute during the last 80 deg. of heating prior to attaining the flash point. As the flash point is approached, a test is made for every 5 deg F rise in temperature (on the readings which are multiples of 5) by slowly passing a small bead-like test flame, or lighted wax taper, not exceeding one-eighth inch in length, across the center of the cup one-fourth inch above the surface of the oil, the movement occupying one second

The temperature when a flame first jumps from the test flame to the oil is called the flash point of the oil. The test must be made where the cup is free from draft and must be made in a subdued light

After the flash point has been obtained, the same method of testing shall be continued until the oil takes fire and continues to burn The temperature at which the oil continues to burn is the fire point of the oil

To extinguish the fire after the fire point has been taken, remove the thermometer and alcohol lamp and then place the lid over the burning oil.

Viscosity Test

Apparatus—

A. Saybolt standard universal viscosimeter.
B. Stop watch.
C. Thermometers. Range 270 deg F

Method.—Viscosity shall be determined by means of the Saybolt standard universal viscosimeter, as described in the

* Prepared by Engineering Division, Air Service.

Proceedings of the American Society for Testing Materials, Vol XIX, Part I, 1919

Viscosity shall be determined at 100 deg F (37 8 deg C), 130 deg. F (54.4 deg C), or 210 deg F (98 9 deg C) The bath shall be held constant within 0 25 deg F (0 14 deg C) at such a temperature as will maintain the desired temperature in the standard oil tube For viscosity determinations at 100 and 130 deg F, oil or water may be used as the bath liquid For viscosity determinations at 210 deg F, oil shall be used as the bath liquid The oil for the bath liquid should be a pale engine oil of at least 350deg F. flash point (open cup). Viscosity determinations shall be made in a room free from drafts and from rapid changes in temperature. All oil introduced into the standard oil tube, either for cleaning or for test, shall first be passed through the strainer

The outer bath is filled with a paraffin engine oil with a flash of about 350 deg to 400 deg. F, and the temperature is adjusted by letting cold water flow through the U-tube or by heating, as may be necessary The tube, which incloses a small jet, is closed by a cork, which is inserted just far enough to be air tight and not nearly far enough to touch the jet. The oil, previously strained into a tin cup and heated to about the required temperature, is poured into the tube until it overflows and fills the cup above the level of the upper end. It is then stirred with a thermometer until the temperature is exactly adjusted The thermometer is withdrawn and the surplus oil is removed from the gallery by a pipette The cork is then withdrawn and the number of seconds occupied in filling the flask to the 60 cc mark is noted by a stop watch and recorded as the viscosity in seconds.

Pour Test

The pour test indicates the temperature at which a sample of oil in a cylindrical container of specified diameter and length will just flow under specified conditions.

Apparatus—The apparatus for the pour test consists of the following:

A Glass jar, approximately 1¼ in. inside diameter and 4 to 5 in high, provided with a tightly fitting cork

B Mercury thermometer, fitted securely in the cork so that the shaft will be held centrally in the jar with the tip of the bulb one-half inch from the bottom. The thermometer specially made for this test has a bulb one-fourth to three-eighths inch long

Method.—Place the oil in the jar to a depth of about 1¼ in. or to a sufficient depth to reach one-fourth inch above the bulb of the thermometer, fit the cork tightly into the jar and place the jar in a freezing mixture At each drop in temperature of 5 deg F remove the jar from the freezing mixture and tilt it just enough to make the oil flow The pour test of the oil shall be taken as 5 deg higher than the reading of the thermometer when the oil has cooled so that it will not flow when the jar is tipped to a horizontal position.

The rate of cooling should be such that the pour test will be completed in about one-half hour

The materials used in the freezing mixture vary with the temperature required to cause the lubricant to solidify. Cracked ice will be sufficient for a temperature above +35 deg F For temperatures between +15 deg and +35 deg F a mixture consisting of 1 volume of salt and 20 volumes of ice may be used. The salt for this purpose should be very dry and fine enough to pass a 20-mesh screen From +15 deg to —5 deg F, ice and salt in the proportions of 1 to 2 are suitable. From 0 deg to —25 deg F a mixture of ice and calcium chloride is used For temperatures lower than —5 deg. a mixture of solid carbon dioxide and acetone is more convenient and will produce temperatures of —70 deg F or less.

The carbon dioxide-acetone mixture may be made as follows: Place a sufficient amount of dry acetone in a covered copper or nickel beaker; place the beaker in an ice-salt mixture, and when the acetone reaches +10 deg F or less, add solid carbon dioxide gradually until the desired temperature is reached.

To obtain the solid carbon dioxide, invert an ordinary liquefied carbon-dioxide cylinder, open the valve carefully, and let the gas flow into a chamois-skin bag Rapid evaporation will cause the carbon dioxide to solidify.

Acidity Test

Acidity in oils is generally due to a partial decomposition of the oil with liberation of fatty acids. These latter act as corrosive agents, attacking the metal of machinery, forming "metallic soaps," and producing gumming and thickening of the lubricant.

Properly refined mineral oils are free from acidity, but nearly all animal and vegetable oils possess it more or less.

Lubricating oils should be neutral and show no trace of acids

Apparatus—Litmus paper.

Method—Rub a small quantity of oil on a piece of polished brass or copper. The metal must not turn green after standing for 24 hours.

Another method to determine the acidity of an oil is to wash a small quantity of the oil with distilled water, then drain off the water and place a piece of litmus paper in the water If the litmus paper turns red, acid is present; if the paper turns blue, alkali is present, if there is no change, the oil is neutral The paper should remain unchanged

Book Reviews

PRINCIPLES AND PRACTICE OF AERIAL NAVIGATION by Lieut. J E Dumbleton, 168 pages and 79 figures published by Crosby Lockwood & Son, London, England. Price 12/6 net.

The author states in his preface that the book was written as the result of experience in teaching, and because of the paucity of text-books suitable for the use of students. The ample and excellent development of the subject point to teaching experience, as well as to an authoritative knowledge of the subject.

The introductory Chapter 1 furnishes just the introduction which a student of aerial navigation would require. Definitions of great circles, meridians, bearings, transit and bearing, fixing position are no doubt entirely familiar to navigators and surveyors. They are rightly included from the point of view of a man who is making his first studies of the subject of navigation The chapter on magnetism and the remarks on the allowances for magnetic variations are similarly valuable. The methods used in compass adjustment are described very practically. The treatment of course setting is simple and the methods would be of immediate interest and use to the pilot. A number of typical problems are worked out as illustrations.

Some interesting instruments are described such as the aero bearing plate with ground speed sights, an aircraft course and distance indicator and the Wimperis course setting sight The maps and charts will be less interesting to American readers since they deal solely with British examples. The instructions given under "Aerial Navigation in Practice" are such as could be followed by any pilot making a cross-country journey.

A STUDY OF THE EFFECT OF KILN DRYING ON THE STRENGTH OF AIRPLANE WOODS, Synopsis of Report No. 68, National Advisory Committee for Aeronautics.

The belief that kiln drying necessarily makes wood brash or "takes the life out of it" is discredited in a recent report entitled "A Study of the Effect of Kiln Drying on the Strength of Airplane Woods," issued by the National Advisory Committee for Aeronautics.

This report contains the results and discussion of tests on fourteen of twenty-six species tested at the Forest Products Laboratory, Madison, Wisconsin, to find the effect of kiln drying on strength.

The chief conclusions are:

"Proper kiln drying produces material fully equal to carefully air dried stock.

"Through improper kiln drying wood may have its strength properties, particularly its toughness or resistance to shock, seriously damaged without visible evidence of such damage.

"The effect of a given kiln drying process is not the same on all species."

Safe limits of temperature and relative humidity to be used in drying the several species are given in this report.

The Aviation Question

The extent and tendency of probable aerial development afford opportunity for wide speculation. The imagination is apt to take long flights when considering this subject. Notwithstanding the marvelous progress made during the war, aviation is still so novel and its possibilities are still so unexplored that it is not surprising that men and governments are slow to grasp the advantages attending human mastery of the air.

Before considering the future place of aviation as an arm of national defense, a few of the claims made by air experts should be discussed. They hold that anti-aircraft devices developed during the war were ineffectual in preventing aerial operations. Not more than one-tenth of one per cent of airplanes crossing enemy lines were shot down by these devices. Hence it is held that these or better devices, used from the cramped and moving decks of battleships, would be useless. The only effective defense against aircraft, they hold is aircraft.

It does not appear that a battleship has ever been sunk in warfare by an airplane, but this fact proves nothing. Aviation was not fully developed during the war. It is a young art, and its followers do not have the advantage of thousands of years of historic experience upon which to draw for hints and warnings. Every aviator is an Icarus and a Columbus. He makes his own precedents and develops his art as he flies. Many a winged lad, in the stress of airy battle, improvised methods which hurried aviation into new fields of usefulness.

Aviators contend that an airplane has from five to eight times greater speed than battleships, that a battleship cannot hide or screen itself, or get away, either by day or night, but is always a target of aerial missiles. It is claimed that air projectiles score a percentage of hits forty times greater than the percentage reached by battleships' guns at a range of 40,000 yards. The assertion is also made that a target towed over a battleship by an airplane will not be hit by the battleship's anti aircraft guns, and that a battleship would have the utmost difficulty picking up an airplane by searchlight at night. Then the argument is made that it is worth the while of Congress to inquire fully into the relative qualities of airplanes and naval craft in offense and defense, inasmuch as an airplane costing $40,000 may be able to destroy a battleship costing $20,000,000.

The proper place of aviation in the executive departments is causing much comment and argument. Should there be a Department of National Defense, comprising Subdepartments of War, Navy and Aviation? This is suggested by some students of the subject, but it does not appear to be a logical development, for this reason: No single department of defense could possibly include all agencies of defense. The Department of State is part of the war machine in time of war, and the Treasury Department is in charge of the very sinews of war. The Postoffice, Interior, Justice and other departments participate in war. In short, all the executive departments are parts of a grand department of national defense at the head of which stands the President as commander-in-chief of the Army and Navy.

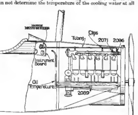
There have been two elements upon which man has fought wars—land and water. Broadly speaking, wars have been fought by armies on land and by navies on the water, although soldiers have often fought at sea and sailors have fought on land. Now another element has been added, which is neither land nor sea. The peculiarities of this element are as many and varied as are the peculiarities of land or sea, and the requirements imposed upon man in fighting in this element are such that neither land nor sea equipment or usage is of any use. The strategy of the air differs from the strategy of an Army or Navy. The tactics differ still more widely. The technical training for one does not fit a man for service in the other.

Since it is evident that war cannot be fought successfully hereafter by any nation which ignores the air as a field of operations, it seems obvious that the logical development of American defense would require the creation of a Department of Aviation, as distinct as the War or Navy Department, and with equal independence. The Air Services that are springing into being should be concentrated in one department, for the sake of efficiency by standardization and technical progress.

If the Postoffice Department needs airplanes and aviators it should get them from the Department of Aviation. Both in times of peace and war the War and Navy Departments work harmoniously, and there is no reason why a department of Aviation should not cooperate with them.—*The Washington Post.*

Water Temperature Indicators

It has often been said that most of the instruments now seen in airplanes might be done away with by very experienced pilots. It is not very difficult for an experienced man to estimate his attitude, airspeed, and the r p.m. of the engines but he can not determine the temperature of the cooling water at all



THE BOYCE DISTANCE TYPE MOTOMETER

accurately without an instrument. In commercial flying it is essential that the utmost economy of fuel be practised to make a profit One of the most important ways of doing this is to properly regulate the temperature of the cooling water Should an engine overheat badly, it usually results in an expensive repair job

The distance types of Boyce Motometer provide a means of accurately determining the approach of dangerous conditions and the effect of controlling measures such as the operation of the radiator shutters.

Washington Site for McCook Field

An area in Benning, D C, and a section of College Park, Md adjacent to the District have been suggested as flying field locations for the engineering branch of the Army Air Service, in a letter sent to Gen C T Menoher, Chief of the Air Service, by Philip King, president of the Merchants and Manufacturers Association.

The Benning site is bounded on the east by Anacostia road, on the west by the proposed Anacostia Park, on the north by the District line and on the south by Benning road. The length of the field is one and three quarter miles and its width is one and one half miles. This site could be extended into Maryland or Anacostia Park and most of the area is owned by the Government.

The College Park site is an area that extends from Ashland Avenue north along the railroad to Waugh Avenue, about two miles long and three quarters of a mile wide. There is an electric car line one block from the field, and the Baltimore boulevard is two blocks away.

Several other sites were recommended to General Menoher by the association.

Rebuilt Air Mail Plane

The mechanics of the Cleveland Air Mail Field have built a mail plane from several old crashed airplanes. The equipment used in this work of rebuilding did not exceed $800 in value. The mechanics of the Air Mail at the various fields reconstruct out of crashed ship salvage an average of one airplane a month

Ship No 99 that was built at Cleveland of parts salvaged from old 99, 95 and other wrecks was put into commission October 6, 1920. From October 6 to October 31, twenty-two days excluding Sundays, this ship completed twenty-two trips between Cleveland and Chicago.

From October 6 to December 31, it completed sixty-three trips between Clevland and Chicago in seventy-three consecutive flying days and in addition made round trips on the New York Division to Greenville, Pa, and Bellefonte, Pa Its total mileage October 6 to December 31 was 21,033 Three motors were used during this period

This ship has been forced to land five times, twice on account of oil pressure, once on account of a leaking gas tank, and twice on account of weather.

During the month of November, this ship covered 7615 miles at an average speed of 95 75 m p h. It flew 3645 miles in an eastward direction at an average speed of 106 84 m.p h. and 3970 miles in a westward direction at an average speed of 84 65 m.p h.

First Photograph of the Dismal Swamp

Charles Frederick Stansbury, author and journalist, who has made a study of the great Dismal Swamp of Virginia for fifteen years and written extensively about it, flew over the swamp in a seaplane January 1, taking photographs of Lake Drummond and the swamp region from the sky. The flying boat was the first ship that ever rested on the surface of the historic lake, which was carefully explored and photographed.

Mr Stansbury was accompanied by W L Hamilton of the Fairchild Aerial Camera Corp. The pilot was Lieut. John M Miller The trip was made in a Curtiss Seagull and was entirely successful, excellent and extensive views of the "Great Dismal" and its world famous lake being secured. Mr Stansbury, piloted by Lieut Miller, flew from Port Washington, Long Island, December 28, having been five and one-half hours in the air, the distance being approximately 320 miles.

Landing Field Established at Camp Upton

A landing field has been located at Camp Upton (Yaphank), 8 miles north of Smith Point, Long Island To reach Camp Upton follow the asphalt road northward from the shore The field is easily recognized in the center of a large group of barracks by a large white circle with "Camp Upton" in the center The field is one-half-mile east and west and 200 yd north and south, slightly rolling and rough in places, with short grass The eastern end of the field is the best. Two roads cross the field from north to south, one road in the extreme west should not be crossed. Fast planes of DH-4 type may be landed in the eastern end of the field if care is used Gas and oil may be obtained from the United States Army garage

One Accident in 326,000 Miles Flown

The unfortunate accident to the Handley Page airplane in which three lives were lost has brought out certain interesting comparative figures

This is the first accident which has occurred in connection with the Handley Page Air services between London, Paris, Brussels and Amsterdam since September, 1919, when the service was begun. During this period over 4,000 passengers have been safely carried to their destinations, the total mileage flown being over 326,000 miles.

French President to Have Airplane

President Millerand is reported to have ordered an airplane limousine for the purpose of making official visits to foreign capitals and cities in the provinces.

Long Cold Weather Flight

Covering a distance of 2300 miles in temperatures varying from 45 above to 45 below zero, two Larsen all-metal planes completed on January 10 a flight from Larsen Field, Long Island to Edmonton, Alberta. Starting December 10 the two planes were piloted by H. T. Lewis and H. S. Meyers, Larsen Aircraft Corp pilots. Each machine carried a mechanic, while Captains May and Gorman formerly of the Canadian Air Force rode as passengers, the latter having come to New York to deliver the machines to commercial interests of Edmonton for aerial survey work between that place and the arctic circle

The trip was made in leisurely hops with stops at Cleveland, Chicago, Minneapolis, Brandon, Man and at Saskatoon, where the fliers of the Army's Alaskan Expedition also stopped. Actual time of the machines in the air totalled 29 hours and 38 minutes.

From Minneapolis north the machines flew by compass at an average altitude of 600 feet above the clouds experiencing intense cold The only difficulties encountered were those arising from ice on the propellers and taking off from snow covered fields where the wheels sank in snow For the work in northern Canada ski landing gears will be used.

Naval Aviation Pigeons

The Navy Department has received a report from Pensacola concerning aviation pigeons. During the week of December 6 a total of thirty-two birds were used by the airplanes of the various departments in delivering important messages. A distance of 700 miles was covered by the birds in this work and their average speed was 32 m.p.h. These pigeons are always carried aboard when the airplanes are on duty that takes them away from the station.

All Naval Aviation pigeons are kept by number on the station muster sheet in a manner similar to that employed in keeping a record of the personnel attached to the station. Young birds, however, are not put on the muster sheet until their legs have grown large enough to hold their Naval Air Station band number

Reserve Officer Schools

Six Reserve Officer Training Corps Units of the Air Service have been ordered established by the Secretary of War and are located at the following colleges

Georgia School of Technology, Atlanta, Ga., Massachusetts Institute of Technology, Boston, Mass, University of California, Berkeley, Cal., University of Illinois, Urbana, Ill., University of Washington, Seattle, Wash, Agricultural and Mechanical College of Texas, College Station, Tex.

Aircraft Sales and Service Co. Organizes

The Aircraft Sales Co has organized with offices at 514 Lyric Theater Building, Cincinnati, Ohio. This company has taken over the interests and equipment of the Pan-American Aeroplane Exchange and will carry on an aeronautical brokerage similar to that of the Pan-American but will have a more complete service and act as booking agent for some of the leading aerial transportation and educational institutions of the country

State Legislator Flies to Capitol

Airplane commuting has been adopted by G. E. Davidson, Republican member from Arnett, Ellis county, Oklahoma, of the lower house of the Oklahoma legislature. He arrived in Oklahoma City recently flying his own plane. He circled over the capitol, dropping pamphlets before descending He said he intended to fly to and from Arnett during the season whenever the weather permits.

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